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Upper Hudson River Sedtran Model
Topic 3: Model Structure → Current Model

December 7, 2010

Bed Shear Stress: Skin Friction

$$\tau_{sf} = \rho_w C_f u^2$$

$$C_f = \kappa^2 \ln^{-2}(11\, z_{ref}/k_s)$$

$$k_s = 2D_{90}$$

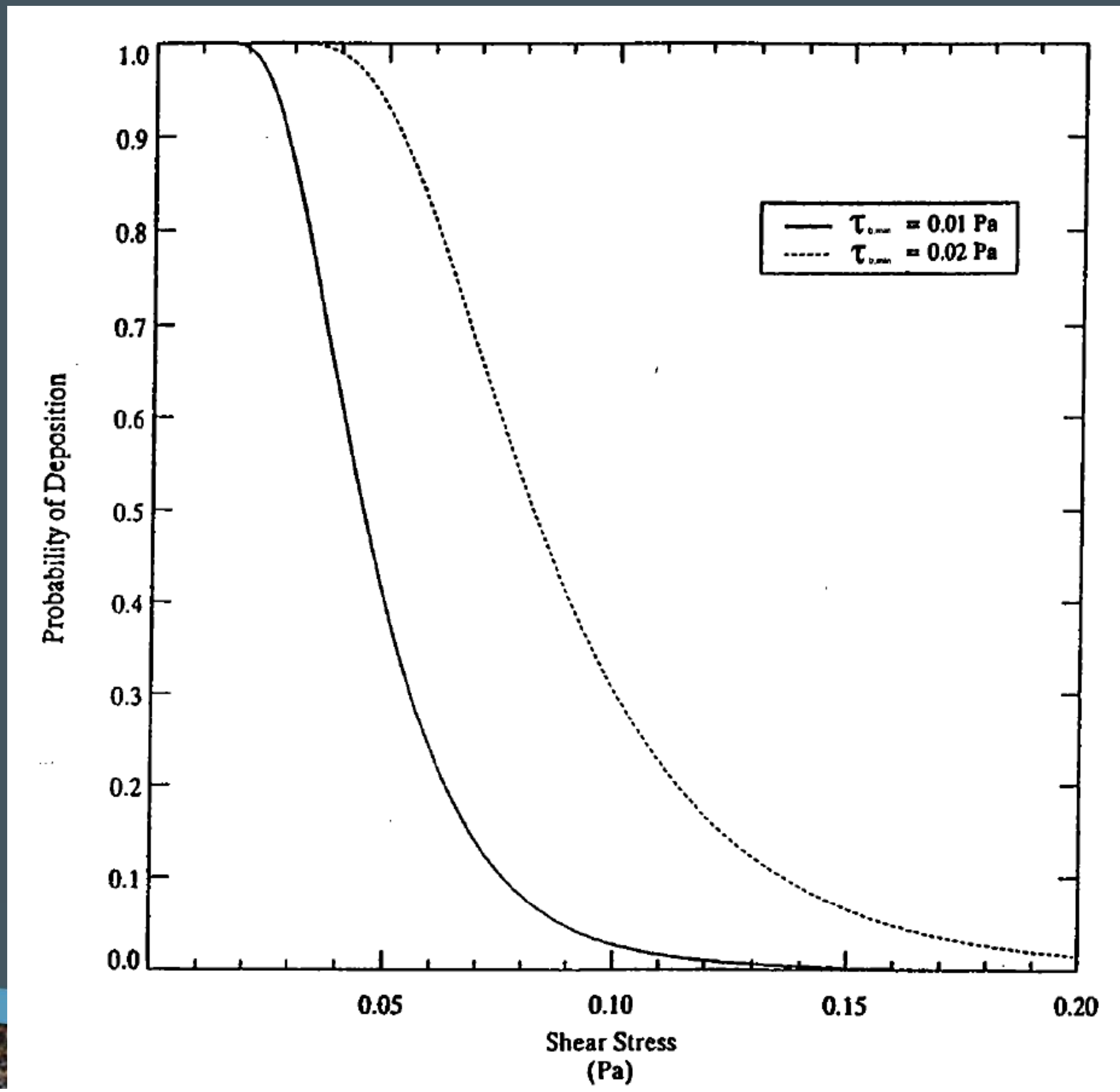
- Where:
  - ρ_w = water density
  - C_f = bottom friction coefficient
  - u = near-bed velocity
  - z_{ref} = reference height above bed (h, water depth)
  - k_s = effective bed roughness

Deposition Flux: Size Class k

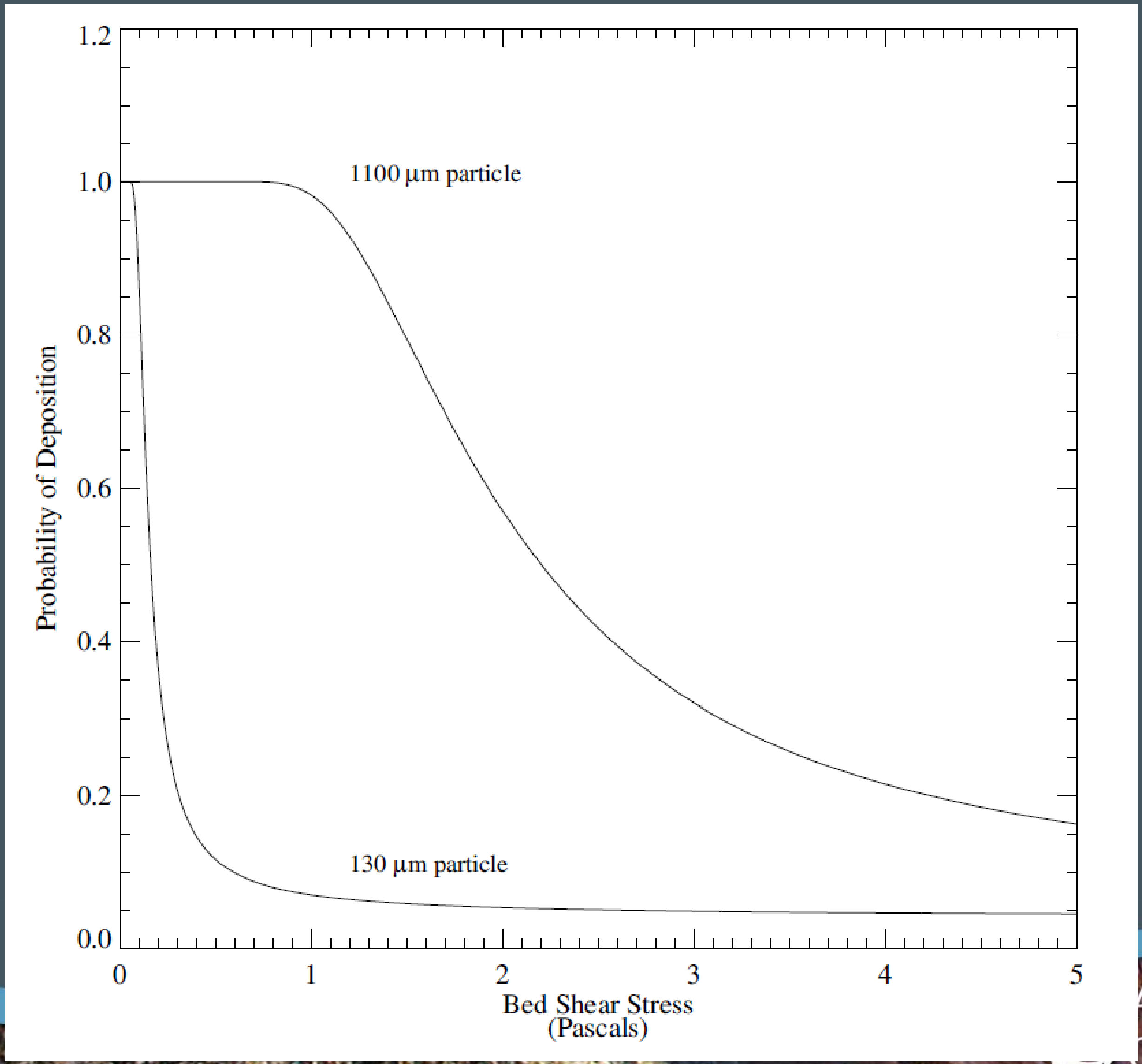
$$D_k = P_{dep,k} \, W_{s,k} \, C_k$$

- Where:
  - $P_{dep,k}$ = probability of deposition for size class k
  - $W_{s,k}$ = settling speed for size class k
  - C_k = near-bed concentration for size class k
- D_k has units of g/cm^2-s

Probability of Deposition:
Cohesive Class



Probability of Deposition:
Non-Cohesive Classes



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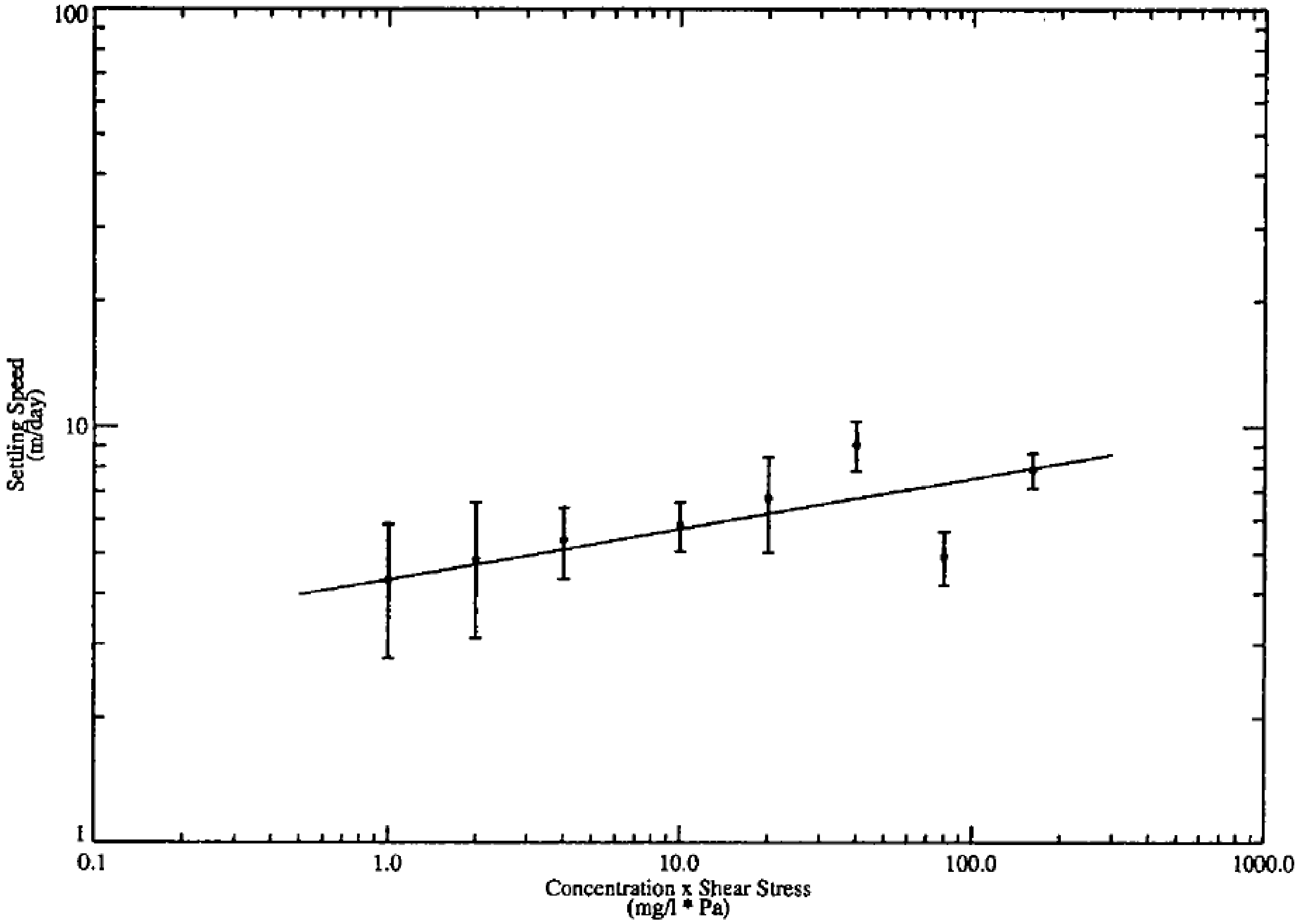
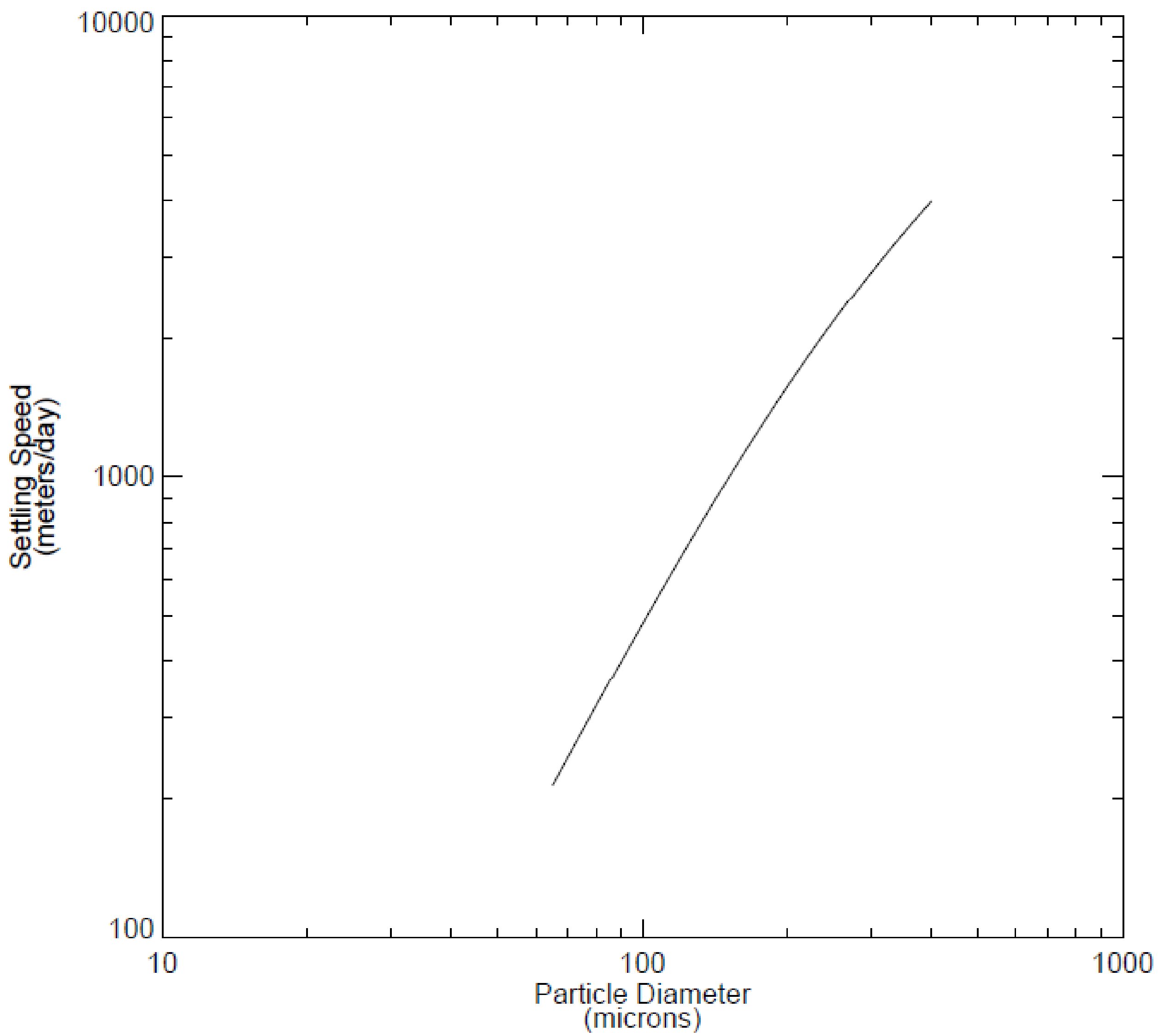
Settling Speed: Cohesive Class



Settling Speed: Non-Cohesive Classes



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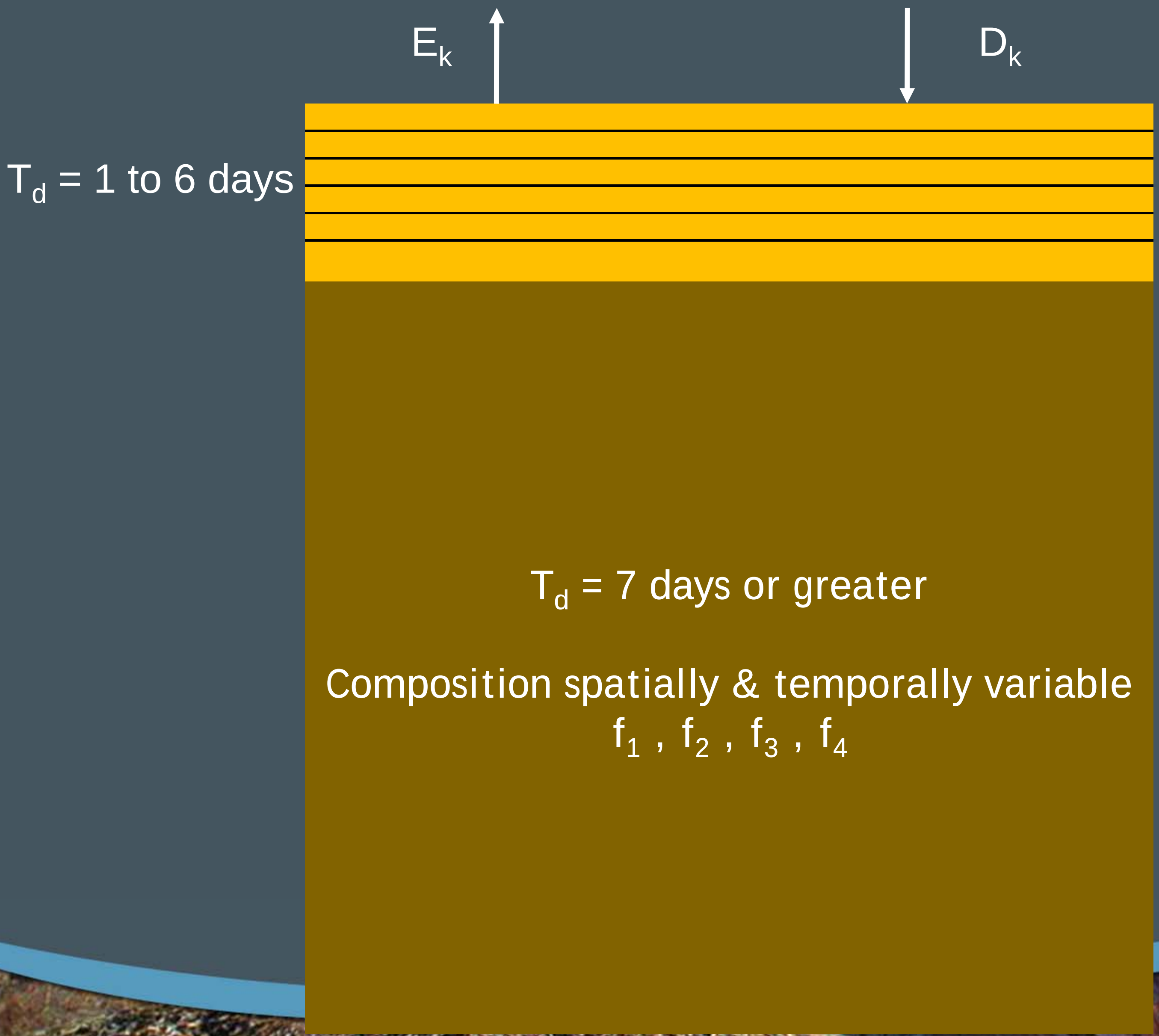
Cohesive Bed Erosion: Lick Equation

$$\varepsilon = \frac{a_o}{T_d^m}\left(\frac{\tau - \tau_{cr}}{\tau_{cr}}\right)^n, \tau > \tau_{cr}$$

- Where:
  - ε = resuspension potential (g/cm^2)
  - T_d = time after deposition
  - τ_{cr} = critical shear stress
  - a_o = site-specific coefficient

Cohesive Bed Model



Non-Cohesive Bed Erosion

- Suspended load erosion from the non-cohesive bed is simulated using the van Rijn algorithm
- Bed model simulates the effects of bed armoring

Non-Cohesive Bed Erosion:
Erosion Rate of Size Class k

$$E_k = f_{AS,k}\, S_k\, P_{sus,k}\, E_{na,k}$$

- Where:
  - $f_{AS,k}$ = content of class k in active-surface layer
  - S_k = particle-shielding factor for class k
  - $P_{sus,k}$ = probability of suspension for class k
  - $E_{na,k}$ = erosion rate for non-armoring bed, class k

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Non-Cohesive Bed Erosion:
Probability of Suspension, Size Class k

$$P_{sus,k} = 0 \quad \text{for } \tau_{sf} \le \tau_{c,k}$$

$$= [\ln(\beta_1) - \ln(\beta_2)]/[1.39 - \ln(\beta_2)] \quad \text{for } \tau_{sf} \ge \tau \text{ and } \beta_1 \le 4$$

$$= 1 \quad \text{for } \beta_1 > 4$$

- Where:
  - β_1, β_2 depend on u_* (shear velocity) and $W_{s,k}$ (settling speed, class k)
  - Settling speed of sands are related to effective particle diameter (d_k)
- P_{sus} for class 1 (clay/silt) is equal to one

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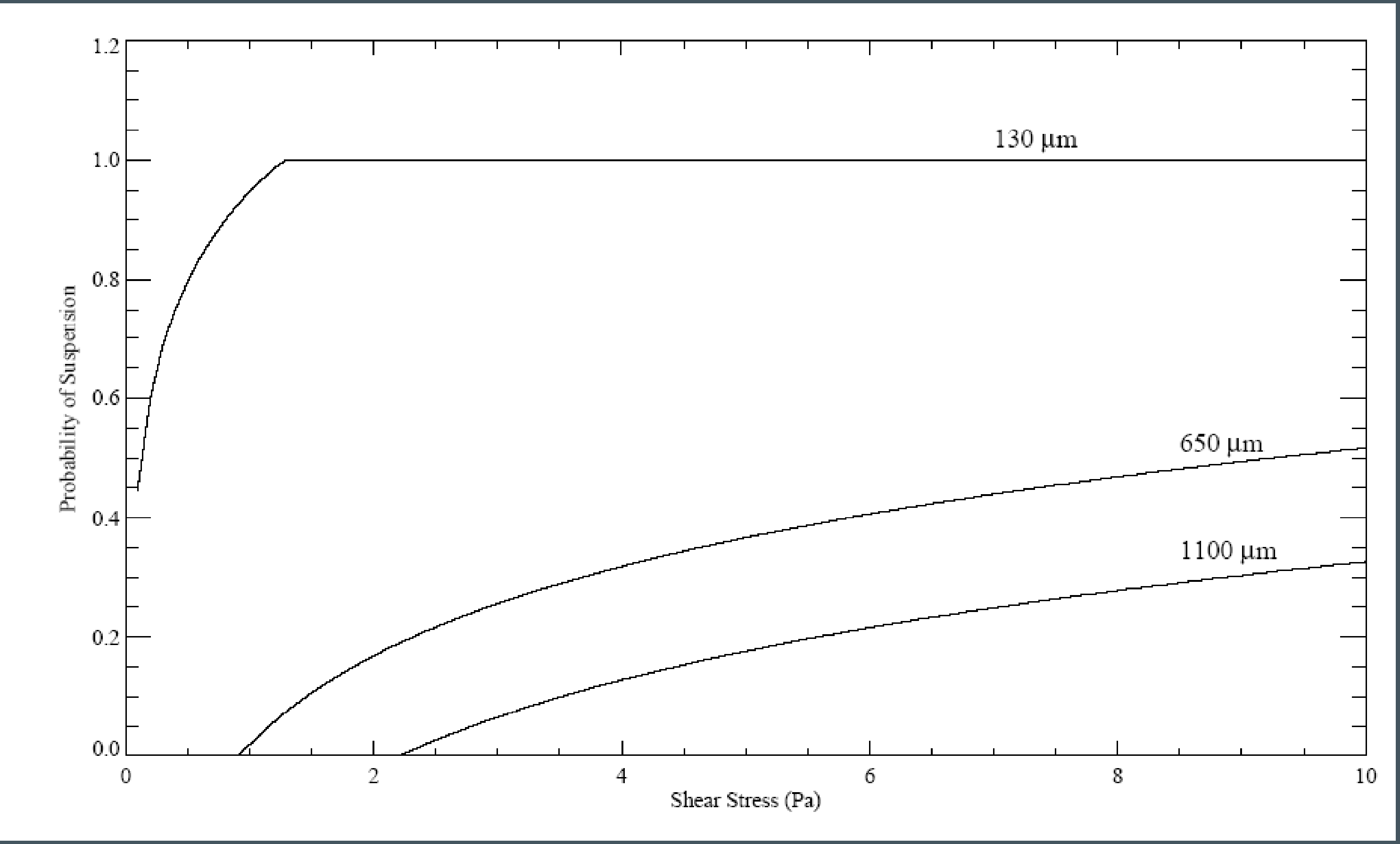
Non-Cohesive Bed Erosion: Probability of Suspension, Size Class k



Probability of suspension as a function of bed shear stress and particle diameter.

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Non-Cohesive Bed Erosion:
Particle-Shielding Factor, Size Class k

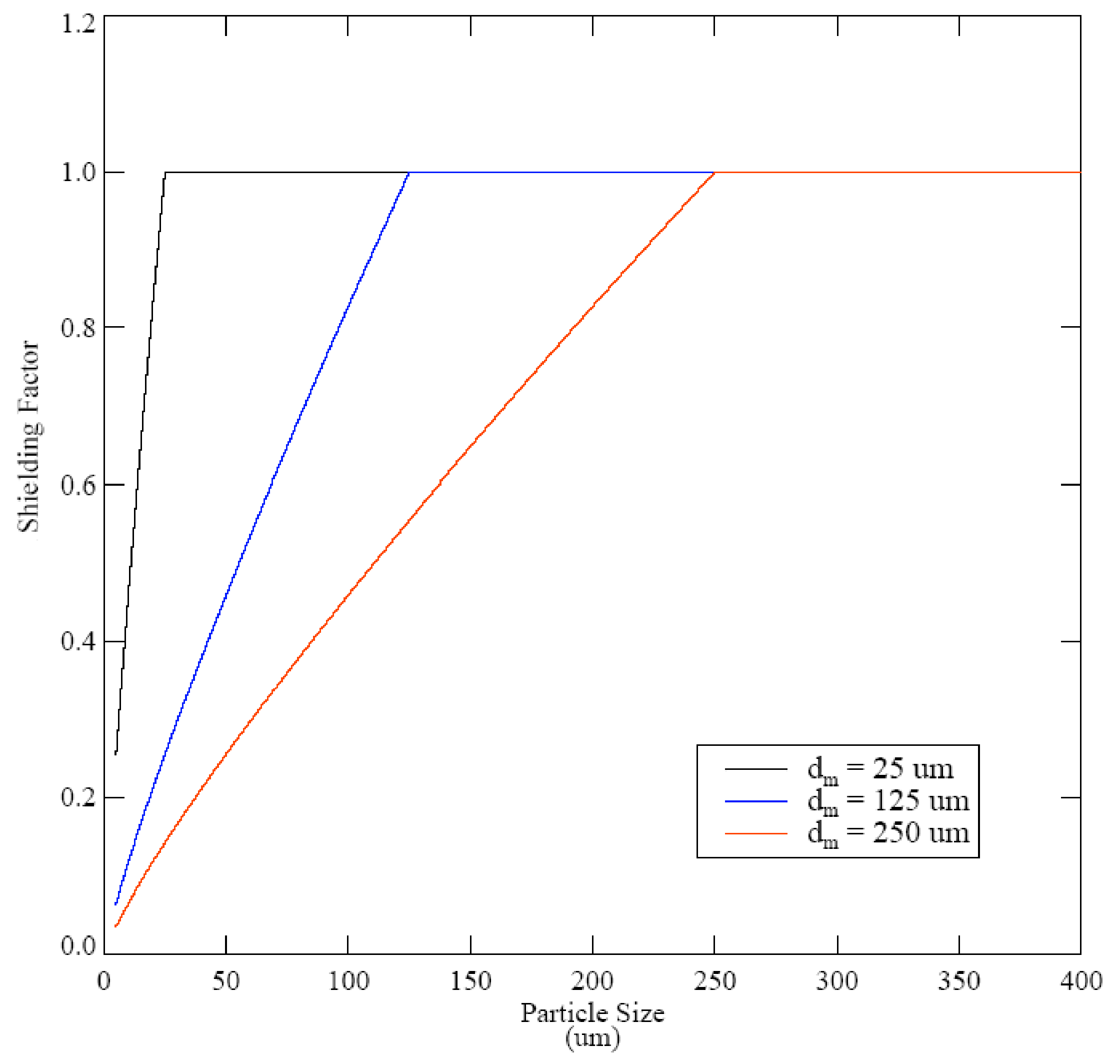
$$S_k = (d_k/d_m)^{0.85} \quad \text{for } d_k \leq d_m$$

$$= 1 \quad \text{for } d_k > d_m$$

d_{50}

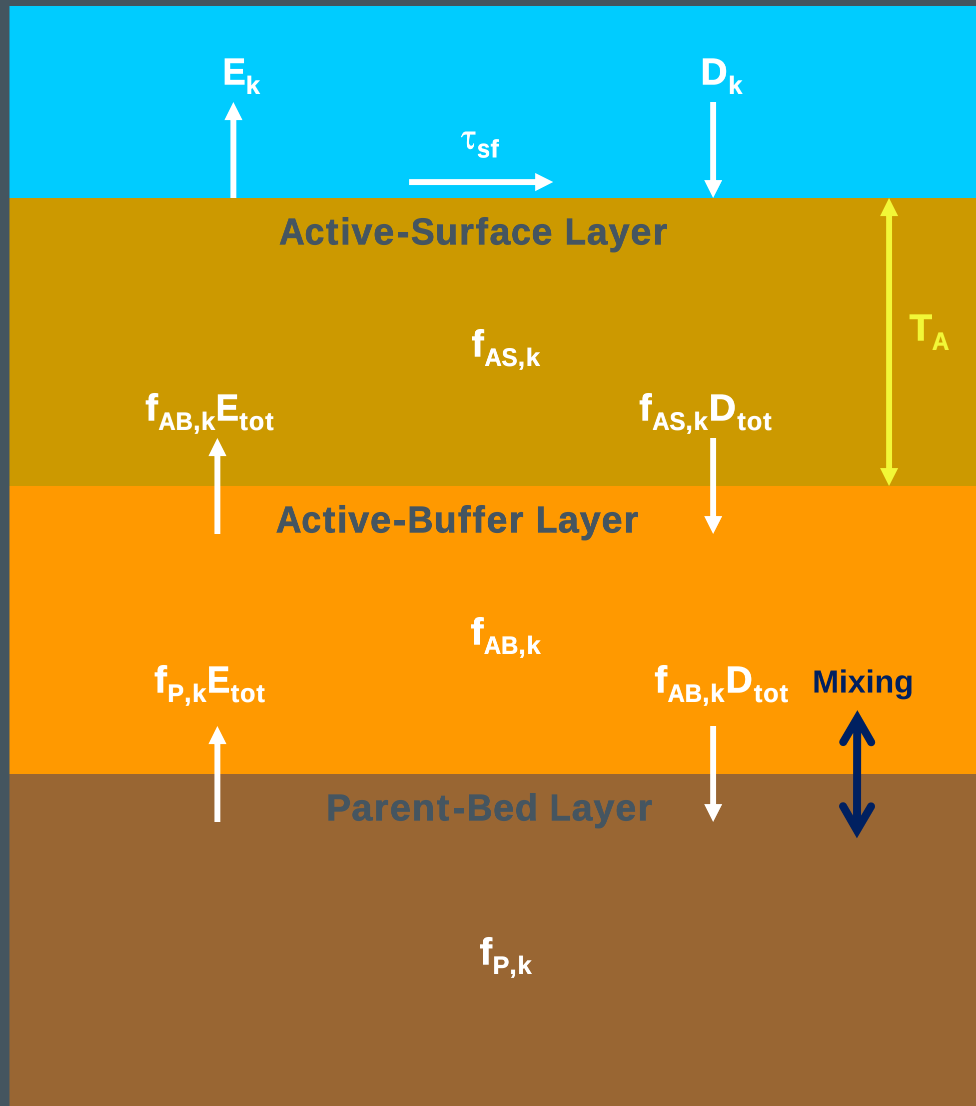
- Where:
  - d_k = effective particle diameter, size class k
  - d_{50} = median diameter in parent-bed layer

Non-Cohesive Bed Erosion:
Particle-Shielding Factor, Size Class k



$E_{tot} = \Sigma E_k$

$D_{tot} = \Sigma D_k$



$= 2\ d_m\ (\tau_{sf} / \tau_{cr})^n$

d_m = mean diameter

τ_{sf} = skin friction shear stress

τ_{cr} = critical shear stress

n = adjustable exponent (0.2)

Schematic of interactions between the water column, active layer, and parent-bed layer when the active-buffer layer is present.